Signal Coordination Management and Control Design of Main Road Based on Bus Priority

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ABSTRACT

The research on the coordinated control and management of main road signal can alleviate the traffic congestion of urban main road to a certain extent, and effectively improve the traffic capacity of the road. The existing main road signal coordination management and control mainly considers the traffic efficiency of social vehicles, which conflicts with the bus priority development strategy. This paper presents a coordinated control method of main road signal based on bus priority. The key point of the method is to coordinate the social vehicles and buses in the green wave scheme, which combines the characteristics of slow running speed of public transport with the characteristics of stopping passengers. In the design of green wave scheme, a green wave band passing speed based on the operation characteristics of public transport is adopted. At the same time, a special entrance lane is given to the bus when the vehicle arrives at the intersection. According to this control mode, VISSIM simulation software is used to control the traffic organization of intersections along Fenghe North Avenue in Nanchang city. The simulation results show that the design scheme based on the implementation of green wave control reduces the bus delay and average travel time at the intersection.

Keywords: *Arteries Coordinated Control, Bus Priority, VISSIM Simulation.*

1. INTRODUCTION

With the continuous improvement of the trend of urban motorization, urban road traffic problems need to be solved urgently. However, for the built urban areas, if they want to implement large-scale projects to alleviate traffic congestion, they will be limited by many practical factors such as road space conditions, politics and economy [1]. A large number of studies and examples show that the design of signal linkage control for intersections along urban roads is conducive to improve the road capacity. At the same time, public transport priority is the inevitable trend of Urban Road Development in the future [2]. Therefore, this paper introduces a design method which takes bus priority into account in the signal linkage control of urban road multi intersections [3]. In the design of green wave scheme, considering the characteristics of slow travel speed of public transport, platform layout and public transport stop and get on and off, combining with the geometric conditions of the road, the priority of social vehicles and public transport is coordinated in the linkage control.

2. COORDINATED MANAGEMENT AND CONTROL DESIGN OF MAIN ROAD SIGNAL BASED ON BUS PRIORITY

The key to consider public transport priority in online control system is to coordinate the two as much as possible, that is, on the basis of realizing public transport priority without destroying, or less damaging the linkage control signal of main roads and multiple intersections [4]. This design mainly starts from the geometric conditions of intersections and the driving characteristics of public transport, and embodies the consideration based on public transport priority in the linkage control of multiple intersections [5]. The overall framework of the design scheme is shown in Figure 1.

Considering the slow speed of public transportation and the need to stop between each intersection to get on and off passengers, a green wave scheme is designed, which takes the speed of public transportation as the passing speed. It is proposed to set the traveling speed of the public transportation section as V_R, the time of

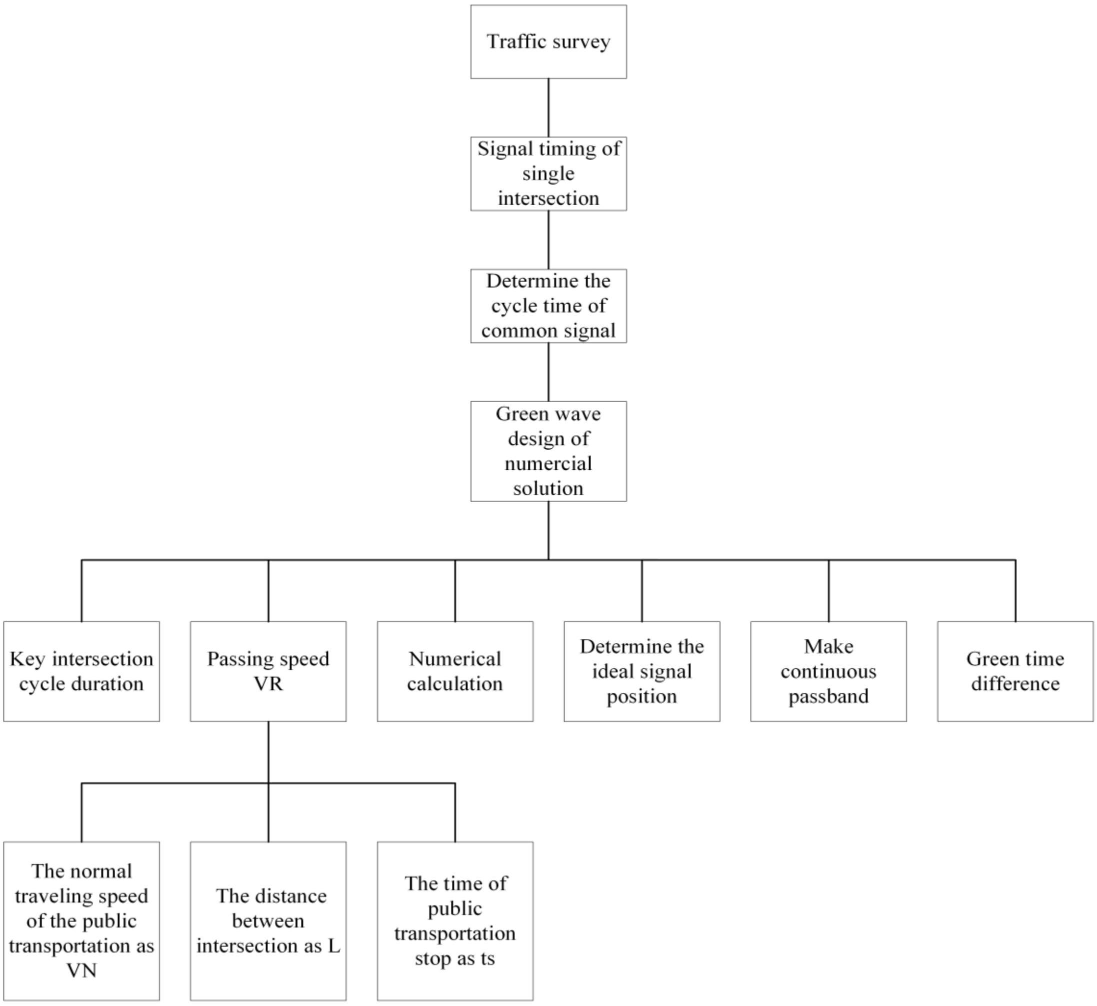

Figure 1 The design steps

the public transportation stop as t_s , the normal traveling speed of the public transportation as V_N , and the distance between intersections as L , then the traveling speed of the public transportation on the section is calculated as follows:

$$V_R = L / (t_s + L / V_N) \quad (1)$$

Among them, L and t_s are obtained through actual investigation, V_N takes 30km / h, calculates the driving speed of buses on the road section and takes the average value [6]. Taking this velocity as the velocity of the passing band, the green wave scheme is designed by using the numerical method.

The effect of the design scheme should not only be analyzed qualitatively, but also quantitatively through the data reflection [7]. In the design, VISSIM simulation software is used to simulate the linkage control system of Fenghe North Avenue and the green wave design scheme based on bus priority. The simulation mainly outputs the evaluation parameters such as travel time, delay and queue length.

In the delay calculation, because in the urban road traffic, the bus occupies several times of the road space as the social vehicle, but the bus carrying capacity is significantly larger than the car. Therefore, based on the human-oriented design idea, this paper calculates the total human delay of the intersection according to the average vehicle delay output by VISSIM simulation software, so as to evaluate the effect of the linkage control scheme [8].

Assume that the average passenger capacity of a social vehicle is P_a, the average passenger capacity of a bus is P_b, mainly considering the total human delay of the North-South main road. Then the calculation formula of total delay is:

$$D = P_a Q_a d_a + P_b Q_b d_b \quad (2)$$

In the formula, D represents the total human delay of the design scheme; P_a value is 40, P_b value is 4; Q_a and Q_b represent the total number of two-way vehicles of social vehicles and buses respectively; D_a and D_b

represent the average two-way vehicle delay of social vehicles and buses respectively [9].

3. EXEXPLIFICATION ANALYSIS

This paper takes Fenghe North Avenue as an example. Only direct transit vehicles are considered in the analysis, and left-right transit is not included in the analysis.

According to the actual investigation results, the average bus stop time is 20s, the normal running speed is 30km / h, and the average running speed of the road section is 21.0km/h, which is taken as the passing belt speed to design the green wave scheme [10].

Through the VISSIM simulation, the travel time, queue length and delay of vehicles based on social vehicle and bus can be obtained respectively. Figure 2 for the simulated road network. The simulation intersection is shown in Figure 3 and Figure 4.

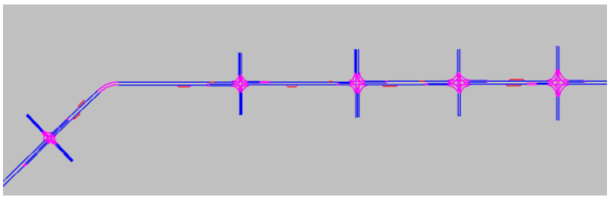

Figure 2 The simulated road network

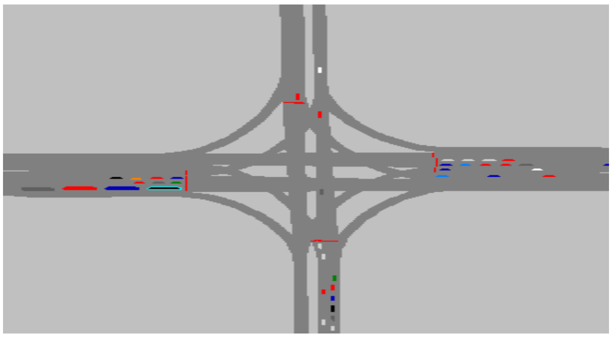

Figure 3 Vehicle queuing

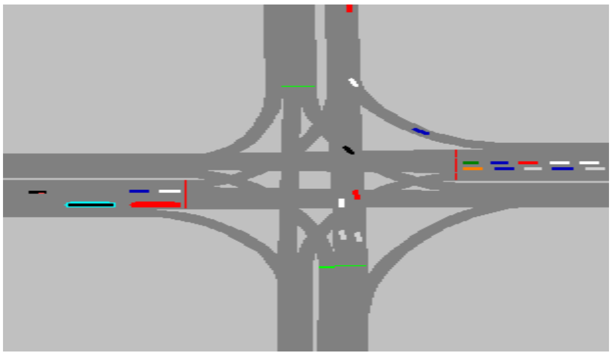

Figure 4 Bus priority at intersections

3.1. Travel Time

According to the comparison of the average travel time of the two schemes in Figure 5 and Figure 6, it can be seen that the average travel time of the social vehicles in the current scheme and the improvement scheme is almost the same, while the average travel time of the buses has been reduced. This shows that the improvement scheme has a good effect on the transit of public transport, and almost does not affect the transit of social vehicles.

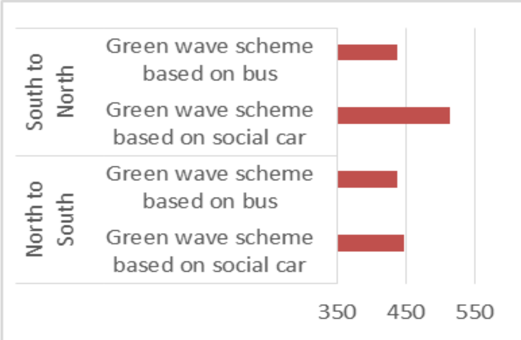

Figure 5 Comparison of bus average travel time

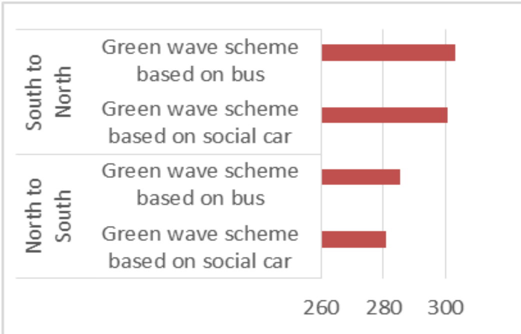

Figure 6 Comparison of car average travel time

3.2. Queue length

According to the simulation output of the average queue length data, the design reflects the priority of public transportation at the intersection, but due to the reduction of the lane width and number, it increases the queuing of social vehicles.

3.3. Delay

It can be seen from the delay data in the Table 4. The average delay changes of social vehicles and buses at intersections are different. Among them, the average delay of buses from south to north decreased significantly. It can be considered that the average delay of vehicles at intersections is reduced.

In urban road traffic, buses occupy several times of the road space of social vehicles, but the capacity of buses is obviously larger than that of cars [11]. Therefore, based on the human-oriented design idea, this design calculates the total human delay of the intersection according to the vehicle delay output by VISSIM simulation software, so as to evaluate the effect of the linkage control scheme [12]. The calculation method of total delay is shown in formula (2), and the results are shown in the Table 5.

According to the total delay of the scheme calculated in Table 5, it is considered that the green wave scheme based on bus is better than that based on social vehicle, which fully embodies the idea of people-oriented.

Table 1. Average travel time

	Vehicle type	Direction	Average travel time(s)	Average number of passing vehicle (pcu)
Green wave scheme based on social car	car	North to South	280.80	75.50
		South to North	300.73	64.00
	bus	North to South	447.93	8.75
		South to North	513.50	5.75
Green wave scheme based on bus	car	North to South	285.60	107.25
		South to North	303.13	86.75
	bus	North to South	438.20	12.50
		South to North	437.35	12.75

Table 2. Average queue length (straight direction)

	Stop line position		Average queue length(m)
Green wave scheme based on social car	Changjiang Road	North entrance	11.00
		South entrance	6.00
	Minjiang Road	North entrance	3.50
		South entrance	2.00
	Zhujiang Road	North entrance	6.80
		South entrance	8.00
	Haojiang Road	North entrance	4.00
		South entrance	6.00
	Xiangjiang Road	North entrance	6.30
		South entrance	21.00

Table 3. Average queue length(straight direction)

	Stop line position	Vehicle type	Average queue length(m)	Stop line position	Vehicle type	Average queue length(m)
Green wave scheme based on social car	Changjiang Road north entrance	car	8.50	Changjiang Road south entrance	car	13.50
		bus	1.75		bus	2.75
	Minjiang Road north entrance	car	7.25	Minjiang Road south entrance	car	5.00
		bus	1.50		bus	1.25
	Zhujiang Road north entrance	car	3.25	Zhujiang Road south entrance	car	9.50
		bus	1.25		bus	0.75
	Haojiang Road north entrance	car	6.25	Haojiang Road south entrance	car	7.25
		bus	1.50		bus	0.00
	Xiangjiang Road north entrance	car	9.00	Xiangjiang Road south entrance	car	2.75
		bus	3.50		bus	0.50

Table 4. Average vehicle delay

	Vehicle type	Direction	Average total vehicle delay (s)
Green wave scheme based on social car	car	North entrance	51.00
		South entrance	76.00
	bus	North entrance	89.60
		South entrance	223.00
Green wave scheme based on bus	car	North entrance	55.70
		South entrance	70.90
	bus	North entrance	93.50
		South entrance	85.30

Table 5. Total delay

	Vehicle type	Total population	Average total vehicle delays(s)	Total delay (s)
Green wave scheme based on social car	car	7696	127.00	1577584
	bus	1920	312.60	
Green wave scheme based on bus	Car	7696	126.60	1317610
	bus	1920	178.80	

4. CONCLUSION

From the simulation results, compared with the signal scheme without green wave control, some vehicles in the green wave control scheme can pass through five intersections or several intersections without stopping. Or the waiting time of vehicles at the intersection stop line is shorter. As far as vehicle queuing is concerned, the queue length of vehicles at both ends of the intersection entrance lane is longer than that of the middle intersection, which reflects to a certain extent that in the simulation of signal linkage control, the green wave effect of intermediate intersection is better than that of other intersections. Some buses can enjoy the effect of green wave control. Because buses need to stop at the bus stop to get on and off, if they fail to catch up with the green wave when they arrive at the intersection, they will increase the bus delay due to the queuing social buses in front of them. On the other hand, the right turn vehicles on the secondary road can't enter the secondary road through the canal island because of the long length of the straight line vehicles. Even if the right turn vehicle is not controlled by the signal, but because the exit is blocked, the right turn vehicle will also participate in the queue at the intersection.

Based on the coordinated control of main road, the optimization scheme considers bus priority from space and time [13]. In space, the number of entrances is increased by compressing the central isolation green belt, and the bus only entrance lane is set to avoid the obstruction of queuing social vehicles in front of the bus arriving at the parking line. When the bus light is green, the bus can pass through the intersection at the first time. According to the simulation results, some vehicles can enjoy the effect of green wave better. If the bus can't pass the intersection, it can be arranged after the stop line, which reduces the delay caused by waiting behind other vehicles.

By comparing the two schemes, it is considered that the bus speed can be calculated by considering the bus stop time and running speed on the basis of the coordinated control of main road signals among multiple intersections of urban road. The green wave scheme with speed can reduce the impact of buses on social vehicles and reduce the delay and average travel of buses at intersections Time.

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